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1 6. Log cover - [Moderate]

1.1 Introduction

Wood habitat restoration discussed in the Stream Habitat Restoration Guidelines (SHRG) is organized under four techniques: 1) Debris Jams, 2) Large Wood Replenishment 3) Log Cover, and 4) Structures to Create and Maintain a Diverse Channel Bedform. In nature, habitat functions aren't organized into four categories. Wood habitat functions change depending on a wide variety of geomorphic, biologic, hydrologic, hydraulic and watershed processes that occur over time. Wood habitat can be variable between and within watersheds. Local watershed knowledge and watershed analysis may be helpful and should be used during the design of wood related habitat to maximize success. Monitoring of a sub-sample of restoration sites is an important aspect of restoration efforts to validate the restoration effort.

Large wood techniques described in the SHRG overlap. For example, a debris jam may also provide log cover. The techniques provided facilitate understanding of natural large wood processes. The goal is to emulate natural processes that benefit aquatic environments through design and construction. This technique is intended to address only cover habitat that has limited interaction with channel hydraulics. It does not address wood placed to maintain pools, sort gravel or encourage upstream backwatering and sediment deposition. Techniques that address hydraulic interaction with large wood material can be viewed in other sections of this document.

1.1.1 Description of Technique

The log cover technique can be described as one or more logs laid on the bank and crossing over a side scour pool as cover and flood refuge or a log buried in the bank cantilevered into the channel. It may also be a log or complex of logs placed in backwatered pools, seasonally flooded areas, and off channel ponds and wetlands. Cover logs can also be placed in long riffle sections to provide cover and refuge to migrating adult salmonids. In all cases the wood or wood complex provides visual protection for rearing habitat and holding habitat from predators.

This technique can also describe wood being placed to provide cover to other aquatic life, entrain or "waylay" other mobile woody debris in bigger flow stages, act as nurse trees for developing woody and other vegetation in the immediate riparian edge, and store and contribute to nutrient entry into the channel. This technique may be viewed as an interim treatment to provide these functions and structure while natural rates of woody debris recruitment through riparian forest regeneration develops. Consider riparian vegetation and management (see riparian technique 5.13) to provide a long-term source of large woody material to the stream and to provide an alternate type of near-bank cover.

1.1.2 Physical and Biological Effects

Bilby and Ward (1989) state that large wood influences the physical form of the channel, retention of organic matter and biological community composition. The presence and abundance of large wood are correlated with growth, abundance and survival of juvenile salmonids (Spalding et al. 1995; Fausch and Northcote 1992). Fausch and Northcote (1992) indicate that size of wood is important for habitat creation. Hicks et al. (1991) indicated that lack of large wood available for recruitment from the riparian zone also leads to reduction in the quality of fish habitat. All of these contributions made by log cover are important components to the stream restoration strategies.

Placement of large wood into streams can result in altered hydraulics that result in scour of the channel bed or bank. This can lead to creation of pools that may influence the distribution and abundance of juvenile salmonids (Beechie and Sibley 1997; Spalding et al. 1995). If placed so as to have moderate to high influence on channel hydraulics, stability, and sediment and nutrient storage (provide some level of guidance as to when that might occur) logs will also influence pool depth, abundance, and complexity, habitat diversity, and spawning gravel quality and deposition. This occurs when the wood begins to hydraulically influence the channel substrate. It is dependent on the size of the substrate around the wood and the shear stress created near the wood as water accelerates around it during variable flows. Substrate scour and deposition are common results when this occurs. This example illustrates the overlap in form and function of large wood that make it difficult generalize separate types of habitat and techniques as they can easily change and evolve over time providing and creating different habitat depending on orientation, mobility and stream discharge. The changes that could occur around any placed large wood should be recognized before construction to insure unintended scour near spawning redds, infrastructure or creation of debris jam in front of a cover log causing flooding doesn't occur.

Down logs serve a variety of functions for wildlife species in addition to salmonids. Smaller logs provide escape cover and shelter for small mammals, amphibians and reptiles (Bull et al 1997). Increased log volume may increase densities of certain amphibians and small mammals (Butts and McComb 2000). Small mammals use logs for runways, which in turn attracts predators of these small mammals (Bull and Henjum 1990). Larger diameter logs, especially hollow logs, provide denning, resting, and litter rearing sites for larger vertebrates such as marten, bobcat and black bears (Bull et al 1997). High densities of large logs and upturned stumps provide security cover for lynx kittens (Koehler and Aubry 1994). Jackstrawed logs provide not only excellent cover for small mammals, but prime foraging habitat for mink, marten and cougar (Bull et al 1997).

Salmonids and other fish require cover habitat throughout their lifecycle. Fish prefer secure safe areas to feed while expending as little energy as possible. They use cover habitat to escape predators and high water velocities. Depending on the body size a salmonid can use cobble, boulders, aquatic vegetation, bubble curtains, depth, overhanging trees and undercut banks for cover. One of the most complex forms of cover in forested environments comes from large wood that has entered the stream channel or adjacent floodplain. Healthy natural channels that have large trees growing next to them provide habitat because the trees, over time, slide, fall or roll into the water. Catastrophic delivery mechanisms such as landslides and debris torrents can deliver large volumes of wood in short periods of time that can be redistributed downstream.

From a fish point of view, cover habitat related to downed wood material changes with the rise and fall of a stream or river. This is especially true in higher stream gradients and/or confined stream channels. Trees or wood above low flow water become important during high flow. At high flows fish seek out lower velocity areas out of the main channel and the wood in flood plains becomes as important for cover habitat at flood flows, as the wood in the main channel is at low flow. Floodplain large wood also provides important habitat for amphibians and small mammals. During over bank flooding, floodplain wood also provides roughness that collects smaller sized large wood and sediment that maintains and encourages the establishment of riparian vegetation. Improving locations available for cover during the range of hydrologic conditions (stage) is one factor that can lead to improved aquatic and fish health.

1.1.3 Application of Technique

The use of this technique assumes the channel boundaries are stable and cover habitat is a limiting factor for salmonids. This technique can be used in both new channel construction and for enhancement in existing stream channels.

1.1.3.1 Biologic Location

Fish like to feed in and around glides and pool habitat where they don't have to expend a lot of energy as food floats past. A cover log or complex located in and around pool and glide areas provides a good location for feeding and resting fish. Cover logs also work well to provide habitat in the flood prone areas outside the bankfull elevation. Wood placement on floodprone areas such as gravel bars, backwater areas and side channels that are seasonally flooded are excellent locations for wood cover habitat. Juvenile fish that can access backwater floodplains can take advantage of extensive terrestrial food sources during higher flows if adequate cover is available to prevent predation. Cover habitat provided in these areas can increase the use of these areas during flood stage.

Cover habitat placed to break up long segments of riffle can be a benefit to migrating adult salmonids. Adult salmonids utilize single and multiple wood pieces to rest under as they migrate upstream.

1.1.3.2 Physical Location

Cover wood habitat works best over existing pools or glides that have little or no overhead cover habitat. An understanding of the geomorphic, hydrologic and hydraulic conditions around the project reach is important factors in properly locating and designing wood cover habitat. For example streams with high sediment loads may bury some cover log configurations that encourage deposition. In wood transport environments large long pieces of wood are required in order to create cover habitat that can exist following flood events. Understanding the basic processes that occur in a watershed will lead one towards locations and configurations that will provide cover habitat that can function at all discharges over time.

Cover log location generally works best when the size and volume of cover wood is matched with the expected bankfull dimensions of the stream channel. Therefore, the size of the wood, location of the site and orientation of wood material should always have high flow stage and velocity in mind during construction. For example if small diameter wood is used in a high velocity area it is could easily be removed from the site or shifted high on the bank. If low flow cover was the objective, the following summer the placed wood material wouldn't provide the cover habitat desired at low flow. It was observed that Dolly Varden preferred cover that extended down to the bottom of pools better than cover near the top and that Dolly Varden age-1 and older increases in pools with added instream cover (Keith and Bjornn 1998).

Finding good stable locations to establish cover habitat requires a good understanding of the size of material (diameter and length) one will be working with and physical setting the channel is in. The goal with each placed wood piece is to understand how it would function naturally with respect to discharge and hydraulics around the proposed restoration or enhancement site. Areas with lower stream energy at high flows often provide good locations to place wood cover habitat. Wood depositional areas have wider flood prone areas and lower gradients than upstream reaches. These natural breaks in slope and width become natural zones that collect wood that is transported to the site from higher energy steeper stream reaches.

1.2 Scale

Wood habitat, function, transport and deposition changes depending on the size of the waterway and wood pieces. Regardless of the size of wood chosen, as one moves from the headwaters of any watershed down to the ocean the function and behavior of that wood changes as the hydrology and geomorphology acting on the wood changes.

In small stream and rivers trees can be large enough to act like bedrock when they fall into the channel. The hydraulic forces acting around the large wood create pools and redistribute or accumulate gravel around the immobile wood debris. In larger stream and rivers, very large immobile trees can accumulate smaller wood that would have normally been transported downstream. Over time, the complexity and size of a single original tree can grow to a lateral or channel-spanning logjam that backwaters entire stream reaches.

As one moves downstream the ability of flood flows to transport larger material becomes greater as stream discharge becomes greater. The size of the tree and location within the watershed are factors controlling where and to what extent wood deposits and habitat is formed or whether wood is transported. Eventually rivers become large enough to transport substantial wood volumes to the ocean and ocean beaches.

Cover habitat can occur and be produced to some degree on most rivers. As the size of the water body grows, the more cover habitat is concentrated in seasonally flooded areas. Here a single or group of logs tends to transport downstream and become deposited above low flow channel conditions.

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Cover habitat in larger rivers is more conducive to seasonally wet backwater or side channel areas.

Higher in the watershed cover habitat can be created in low flow areas using progressively larger and longer material as one moves from the headwaters downstream. To enable low flow cover habitat to function over time, the size, length and configuration of the wood material must be able to withstand bankfull and higher flood events.

1.3 Risk and Uncertainty

Poorly designed or executed projects have a much greater chance of causing damage to infrastructure in urban streams than in wild land environments. Urban streams are often rock lined and confined to quickly convey water to reduce flooding. They tend to be flashy and can be near or under capacity due to increases in peak flow hydrology. The challenge in urban streams is to strike a balance between the desire to improve and create fish habitat without causing flooding or damage to unintended areas.

Booth (1996) notes that extreme increases in flow discharge complicate the use and placement of large wood for channel rehabilitation in urban environments. Limitations to placing wood in urban streams include; management concerns (flooding and damage), hydrologic changes, sediment fluxes, wood recruitment, human intrusion, and aesthetics. He also notes that flow deflection by the wood can cause localized bank erosion or channel incision, reducing or negating the net increase in sediment storage resulting from wood placement.

Therefore, urban stream environments require a higher level of effort in the design portion of projects to insure hydrology, hydraulics and local sediment transport influence of proposed designs does not create flood problems or channel instability. Wood material used should be stabilized to prevent downstream migration into culverts or bridges that could overtop or scour bridge abutments.

Given the correct analysis, design and construction cover logs or multiple cover logs are very applicable to urban environments. Procedures to insure wood ballasting will withstand large floods should be employed or wood material larger than can be moved by the largest floods should be acquired for use at the project site.

Wild land environments have less potential human impacts than urban environments. Wild land environment risk is associated with the type of stream one is working in. The risk of loosing placed large wood material is variable. Larger streams with higher gradients and confined channels carry more risk than small streams with low gradients and unconfined channels. If one is working in a stream channel that tends to transport wood regularly, consideration should be taken to either work on the edge of the stream with small wood or acquire enough tree size and length to insure it will not be transported.

It is important to match the size of wood material used or obtained in a project with its likely function and behavior within the project reach where work is proposed. Understanding and planning around this basic concept will reduce the risk of losing wood placed as cover habitat within a given project area.

There have been contradictory papers completed to evaluate wood placements in forested streams. Slaney (1997) cites an example in Oregon where large wood was restored in an extensive reach of Fish Creek without a watershed assessment. The large wood held for 10 years and then most of it was lost along with 53% of the previously existing pools after the 1996 flood event (a 100-year event) from debris-sediment flows. A watershed analysis with identification of at-risk drainages and slopes could have been used to alter management activities or improved road construction to reduce road related hill slope failures and prevent much of the impact to the restored habitat caused by debris flows. Unfortunately, many of the roads in Fish Creek were decades old and built before an understanding of watershed stability and road construction impacts were fully understood or acknowledged. A more comprehensive study of nearly 4,000 anchored wood structures on over 100 streams on 8 National Forests in Oregon and Washington showed a high level of durability following the major floods in 1996 and 1997. Less than 20% of the structures moved from the original site placement in this study (Heller et al. 2000).

Failures occur when wood placements are not strategically placed, sized or adequately anchored to withstand design flood events. When a basic understanding of geomorphic, hydrologic and hydraulic variables does not exist the risk for failed wood habitat is much greater. What has been learned and accepted is that an understanding of watershed and stream processes are critical to the proper design, placement and long-term function of wood habitat in forested streams. Failure can occur when objectives or designs are flawed due to a poor understanding of biological limiting factors or physical processes. Failure can also occur when objectives are not met because designs are out of phase with the scale needed to achieve positive physical and biological response.

1.4 Data Collection and Assessment

A basic understanding of watersheds history is important before starting any habitat work. To emulate natural process a determination of what level of degradation has occurred should be completed. To consider doing work anywhere there must be a reason for it. An understanding of the watershed and channel stability is a good place to start. For example a watershed that has road or management related impacts that are increasing sediment loads and channel degradation should be addressed prior to improvements in instream habitat.

Assuming the watershed and channel are stable, an assessment of the type of habitat that is limiting production for a fish species of interest would point towards the location and formation of cover habitat. If, for example, a river had elevated stream temperatures in the summer as a limiting factor but a tributary had cold water with poor cover habitat one would prioritize creating cover habitat in the cold water tributary first. Fish and wildlife habitat need and assessments are valuable tools to help point towards where priorities should be. A watershed assessment is a good way to identify and prioritize habitat deficiencies in any watershed (Roni et al. 2002).

An understanding of peak flow hydrology (discharge at various intervals such as bankfull, 2 year, 5 year, 10 year, 25 year etc.) and geomorphic field indicators are important when planning and designing cover habitat in larger streams that can transport or move the wood being used. Professionals experienced in river restoration over time become adept at seeing bankfull dimensions, old flood terraces, bar deposits, wood deposits, sediment gradations and vegetation disturbance patterns at potential restoration or enhancement sites. This knowledge is important because when construction occurs it is during low flow. However, design and wood orientation has to emulate the consequences of flood flow acting on the large wood to have long-term success. One way to check field indicators is to collect cross section information, determine bankfull elevation and high flow discharges and determine stage discharge relationships with a hydraulic model such as HEC RAS. With this information the orientation and location of large wood that best provides long lasting low and high flow cover habitat can more easily be determined. Refer to the Hydraulics Appendix for further information on hydraulic models.

Areas where natural cover habitat exist near the work site are valuable opportunities to study. The size of the wood, orientation, bankfull indicators, cross sectional and longitudinal characteristics, substrate and bank conditions can all be observed and used to help design cover habitat that emulates the physical and biological properties of the natural habitat. These sites are often referred to analog sites and when available should be given greater weight than any other aspect of data collection and analysis. When used together with the other assessments and data a very high degree of precision can be obtained during design and construction.

In smaller streams where the wood is larger than flood water can move analysis is not as critical as locating quality pools where cover habitat would benefit salmonids. Matching wood size with the size of the stream channel is important for project success. In cases most it is difficult to have wood too large for a project but it is easy to have wood too small.

1.5 Methods and Design

Once an understanding of wood size and stream flood stage is completed appropriate wood elevations and orientation that will allow longevity within the project area can be determined. Locations that provide the most biological benefit are in backwater areas, glides, pools and side channels that are seasonal flooded. Wood cover complexes are better than single logs or pieces. The complexity provided in multiple pieces of wood provides more living space for fish. Disadvantages of multiple cover wood pieces are that wood placement, orientation and stability at high flows becomes more challenging. Complex cover habitat in larger streams requires the wood be interconnected and placed in a way that is stable during flood flows. Depending on orientation, size and stream channel, large logs or root wads can increase roughness and backwater to a point where sediment deposits in a pool causing a reduction in pool volume. An understanding of potential backwater at higher discharges created by placed wood is an important design consideration.

Coniferous trees are the best sources of wood since they have the slowest decay rates. Fir trees can last decades and cedars can last centuries in the water. Deciduous tree decay rates are much more rapid and can loose structural integrity within a decade depending on size and the degree of wetting and drying that takes place.

An adequate size of large wood material with enough length to prevent transport off-site is helpful when working in larger streams. When tree or wood length cannot be delivered to the site smaller sized material can be used and anchored to rock or standing green trees to keep it on-site and emulate the ballast or drag force of a larger, longer tree. Wood volume and frequency is best determined within a watershed assessment. How much wood each watershed is capable of producing and where it is most likely to form habitat is highly variable across the region.

Logs can provide cover over pools by placing them in between existing trees with enough mass of the wood on the bank to prevent transport off site. Once the wood is placed it can be oriented up against a downstream tree that prevents the wood from being rotated up and out of the active channel at flood flows. Root wads work well when “hooked” around existing trees into the adjacent forest. If no standing trees are present the same technique can be used by placing wood on the bank in a way that prevents the hydraulic force of the water at flood stage from rotating the cover log out of the low flow pool area. Some times this requires a substantial amount of interconnected bank wood to enable the establishment of cover wood out over a pool. In these cases the wood can be cabled together to form a solid unit that supports the cover wood extending out into a pool. In systems with higher energy locations boulders may be needed to emulate the same rotational resistance as standing riparian vegetation if vegetation is small or developing.

On streams with steeper banks wood can be oriented vertically down into the water column to the bottom of a pool. The mass of the log above the steep angle in to the pool helps keep it in place. Additional wood can be interwoven in between trees to form a stable lattice of cover similar to what occurs when several adjacent trees blow over into a channel. The strength of the mass is greater than the individual pieces at flood flow. In most cases it is always better to think about and understand the direction of flood forces and orient and build the cover in away it will be stable during flood hydraulic forces. Obtaining wood as long as is possible is valuable. For example, wood that is two times greater than channel width provide more options and cover opportunities than using wood that is half the channel length. Stability over flood flows is important. The more wood on the bank above bankfull elevations the more ballast and strength is provided when the end of the wood providing cover, experiences strong hydraulic and floatation forces during flood events. Using short undersized material often requires artificial anchoring or ballasting such as cable, boulders or chain to make up for the difference in mass and length required for natural wood cover. Therefore to fully understand what will be stable it is important to have a geomorphic, hydrologic and local hydraulic understanding of the work area.

Benefits of anchoring are the ability to create habitat using smaller sized wood than would normally stay on site. Disadvantages to cabling are that unless the cabling is done properly it will fail. Ballasting failures using small wood in high energy environments are usually catastrophic since the wood used is naturally transported wood that would normally be deposited in front of larger wood. Natural fiber rope can also be used in small streams with poor access. Rope would be lighter and easier to work with in remote areas. Because of its strength to weight ratio, rope wouldn't work well in high energy systems and should only be used in stream channels with relatively small hydraulic force. It is important to properly locate and anchor material when emulating the behavior and function of large wood material using cut logs.

Large wood cover logs and complexes can cause bed and bank scour. This is primarily due to the reduction in channel capacity resulting in the lateral or vertical expansion of the stream channel to make up for the lost volume from the placed cover wood. One way to reduce bank pressure and erosion is to excavate the area around the wood deposit. This will increase the local cross section where the wood was placed and decrease the pressure placed on the banks during the next flood.
Scour can be a good in terms of creating and maintaining complex pools. If this is needed, refer to technique 5.8. If pool habitat is adequate and scour is unacceptable wood placements should occur so they don't interact with the water column and should be placed above low flow water surface elevations at or above bankfull.

Hydrologists, Fish Biologists, Geomorphologists and Hydraulic Engineers with experience in design, construction and monitoring large wood material may be used especially when working in areas where large wood can be transported off-site.

1.6 Project Implementation

1.6.1 Permitting

Information regarding specific permits necessary to proceed with construction are addressed in Chapter 4. Information that will generally be required to obtain permits for in-stream wood placement include the volume of the wood and rock ballast incorporated in the project, wetland locations, design drawings, site maps, access areas, sediment control plan, and re-vegetation plan for disturbed sites. Biological considerations as they relate to aquatic resources and the endangered species act should be addressed.

1.6.2 Construction

Fish species in water work windows vary by watershed. District Fish Biologists should be consulted to determine exact in water work windows for the stream in question. Experienced oversight is recommended during construction to insure proper placement and fastening of large wood cover.

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Heavy equipment access should match the abilities and size of the equipment used on the project to prevent resource damage such as barked trees, damaged roots banks and limit ground disturbance.

Equipment size should be adequate to comfortably implement the tasks required during construction. Undersized heavy equipment carries a greater risk of mechanical failure, human injury, hydraulic line failure, and resource damage. Cover logs can also be placed using hand winches, chainsaw winches and hand labor if stream and wood material are small enough. Helicopters have successfully placed wood material in remote or difficult to access stream channels. Valley confinement, riparian or upland tree height, wood size and dense vegetation around the stream channel are factors that effect a helicopters ability to place wood accurately and communicate with any ground crew directing placements. These logistical considerations should be considered prior to contracting any helicopter services.

Use of on-site wood resources can greatly simplify construction and reduce costs but, has some environmental consequences. Removal of downed wood adjacent to the channel reduces wildlife habitat. Removing standing trees also reduces wildlife habitat by reducing nesting and future potential snag habitat for birds. An analysis of cumulative impacts should be undertaken to insure the removal of wood doesn't create unintended habitat degradation for other endangered species such as spotted owls. Construction activities should not degrade the watershed and create instability or stream sedimentation.

Protection of the existing riparian zone is a high priority, particularly in drier climates where replacement of the canopy can take decades. The use of walking excavators, winches and hand labor may be required at some sites. However, it should be noted that using smaller equipment to reduce impacts can in fact increase ground impacts if the equipment is undersized for the job. Undersized equipment can create more ground disturbance by having to drag, pull and push large wood that could have been easily lifted with a larger machine.

All heavy equipment should be washed and free of any oil, gas or hydraulic fluid. It is highly recommended that mineral oil be used to replace toxic hydraulic fluid used in most heavy equipment. Spill plans and cleanup kits should be with the contractor and equipment operator at all times in case of any accidental spill.

1.6.3 Cost Estimation

Cost estimates can be highly variable. Wood costs of material and delivery is highly dependent on the quality, quantity, and size of the wood, and on the distance between the source of material and the project site. It can range from free wood to $1000 per tree delivered to the site. The cost to place a cover log varies greatly depending on the distance from an access road and the type of equipment needed to place the wood. Placement of log cover wood using an excavator or other agile heavy equipment can take anywhere from one-half hour to several hours per structure, therefore ranging in cost from $50 to several hundred for installation. Any necessary anchoring will add to the time and material cost and can double cost of installation.

1.6.4 Monitoring and Tracking

Depending on the monitoring objectives physical monitoring, photo monitoring and stability monitoring can all be used to determine the success or failure of wood designs. Pre and post project cross sections in the project area coupled with substrate sampling can be used to determine changes in stream morphology following project implementation. Photo points taken at each cross section are a good way to document the conditions before and after the project Stability monitoring can be completed by tagging the placed wood also enables one to monitor wood that may leave the original site and move downstream. Wood tagging in combination with photo points is the best way to monitor the physical behavior of the wood. Cross section and profile survey work can show the channel response to large wood placements.

Fish use would be best tracked with before and after snorkeling data at the project site. More detailed information on fish use would have to entail a more extensive fish survey to determine whether standing crop or overall abundance of fish in the stream has increased or whether fish prefer the new habitat over habitat outside the project area.

For a comprehensive review of habitat-monitoring protocols, refer to *Inventory and Monitoring of Salmon Habitat in the Pacific Northwest –Directory and Synthesis of Protocols and Management/Research and Volunteers in Washington, Oregon, Idaho, Montana, and British Columbia*[4] and Schuett-Hames, D., Pleus, A., Ward, J., Fox, M., and J. Light. 1999. TFW Monitoring Program method manual for the large woody debris survey. Prepared for the Washington State Dept. of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-004. DNR#106

1.6.5 Contracting Considerations

Construction contracts and time and material contracts are two ways to build wood cover habitat. Time and materials construction provides designers the ability to adjust wood to field conditions found on site. Often unforeseen events create conditions where a field change would make the project better. This is a great advantage to time and materials construction. It assumes a motivated and fair contractor. Most contractors enjoy working on streams and are highly motivated to do quality work.

To insure exact project costs a construction contract is another way to build a project. Construction contracts place more of the financial liability on the contractor. Construction contracts require much more design work because all of the wood placements have to be specified on paper. The disadvantage to construction contracts is there is limited ability to make a change without an adjustment in compensation. In both forms of construction oversight by experienced practitioners is recommended to insure designs are being constructed properly.

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1.7 Operations and Maintenance

Maintenance needs of log cover structures should be determined relative to the design criteria for the structures, and initiated when monitoring indicates that the structures are not performing as intended. Once a project is completed, unless hand crews can adjust the habitat or access is exceptional easy it is not recommended to plan on going back to adjust habitat projects. Ideally, they should be built to stand alone following design and construction. However, in urban areas where the risk associated with cover structures becoming entrained is greater, maintenance to ensure that structures remain in place may be important. Maintenance needs will likely vary greatly depending on whether structures are placed in remote watersheds, or within urbanized settings and relative to the risk of their failure.

1.8 Examples

Rural

Urban

Whatcom Creek is an urban stream channel where a gasoline spill and resulting fire spill necessitated the restoration of the channel following the cleanup. Cover logs were used to provide habitat in the main pools developed during the restoration.

Hanna Creek is a smaller urban stream channel where the same gasoline spill necessitated the complete excavation and removal of existing riparian soil and substrate followed by the reconstruction of a new stream channel. Cover habitat consisting of large wood was extensively used.

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1.10 Photo and Drawing File Names

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